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(54) **PHASED ARRAY ANTENNA ASSEMBLY**

PHASENGESTEUERTE ANTENNENANORDNUNG

ENSEMBLE D'ANTENNE RÉSEAU À COMMANDE DE PHASE

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Description

TECHNOLOGICAL FIELD

[0001] This invention relates to phased array antennas, in particular, to cooling and temperature control mechanisms therefore.

BACKGROUND

[0002] A phased array antenna generally comprises a plurality of individual modules, each having a transmit/receive circuitry. The modules are arranged in an array, usually by mounting each module onto a carrier assembly.

[0003] When mounted onto the carrier assembly, each module is adapted to be connected to additional transmit/receive circuitry so that it may be attached to a mainframe or a control center.

[0004] Electrical work of the modules usually generates heat, which has a negative effect on the electrical performance of power amplifiers comprised within the modules. Therefore, it is required to cool the modules down in order to increase performance of the modules and prevent malfunction thereof.

[0005] In cooling the modules, not only the overall temperature of a single module has an effect on performance, but also the temperature variation between different modules of the same array. Thus, it is also required to maintain a low temperature variation between modules, i.e. maintain a sufficiently uniform temperature across the entire phased array antenna, allowing it to operate properly.

[0006] Cooling of the modules, as any other cooling, may be performed by one or more of the three known mechanisms: radiation, convection and conduction. Common methods for cooling the modules includes a system of cooling pipes adapted for the flow of a cooling fluent therein, thereby removing heat from the modules by convection. Also, it is known to attach to the carrier assembly a radiation plate, thereby further removing heat from the modules by radiation.

[0007] US 2012/0162922 discloses a system including a first circuit board that includes integrated circuits, a first thermal spreader coupled to the integrated circuits of the first circuit board, a first compliant board coupled to the first circuit board, a second circuit board that includes integrated circuits and a second thermal spreader coupled to the integrated circuits of the second circuit board. The first circuit board and the first thermal spreader have a first thickness. The second daughter board and the second thermal spreader have a second thickness. The system further includes a second compliant board coupled to the second circuit board, a board assembly coupled to first and second compliant boards and a cold-plate assembly in contact with the first and second thermal spreaders. Either of the first or the second compliant boards is configured to expand or contract to account for the differences between the first and second thicknesses.

[0008] US 2012/0063098 discloses an assembly to provide thermal cooling including a first member having a first channel configured to receive a cooling fluid, a second member having a second channel configured to receive the cooling fluid, and a first plurality of hollow and flexible conduits connecting the first and second members. Each of the first plurality of hollow and flexible conduits is configured to provide a path for the cooling fluid to flow between the first and second channels.

[0009] JP618858 discloses a device having a moving body SNG device consisting of a transmission-reception module and a bus system, and the module consists of a multilayered substrate plane antenna (subarray), a radome for protection of this plane antenna, and a circuit part arranged as a module on the rear face of the plane antenna. The bus system has a mount part for arrangement of them on the same plane. The circuit part is stored in a shield case. The transmission-reception module is so inserted that it is closely brought into contact with the mount part of the bus system, and the input/output connector of the transmission-reception module. The signal connector of the bus system are connected.

[0010] JP 2011-244266 discloses an antenna composite unit having a coolant passage formed inside of a reflector which is a part of a component in an antenna composite unit, in which the reflector functions as a cold plate of liquid cooling system, The reflector and the cold plate are integrated to be a component. The component is integrally laminated and thermally combined with other components which are an antenna module unit, a drive circuit unit, and a structure body.

[0011] US 2012/0068906 discloses a vertically stacked array antenna structure comprising a radiating layer, a passive layer disposed under said radiating layer, an active layer disposed under said passive layer, and an interface assembly. The radiating layer comprises an array of radiating elements. The passive layer has only passive components. At least a part of the passive components includes an array of RF duplexers corresponding to the array of radiating elements. The active layer comprises RF amplifiers. The interface assembly comprises at least one metallic frame which is in direct thermal coupling with the RF amplifiers. The interface assembly is configured for providing thermal communication of the active layer with a heat exchanger.

[0012] US 2003/0218566 discloses a radar system with a phase-controlled antenna array that contains a number of data and supply networks, which are installed so that they are interchangeable, and a sender/receiver module containing a sender and receiver circuit as well as a number of circulator circuits and a number of antenna elements that are coupled via a circulator circuit to the sender and receiver circuit. Sender and receiver circuits, circulator circuits, and antenna elements are combined in each sender/receiver module and the sender/receiver modules are arranged interchangeably on the radiation side of the radar system.

GENERAL DESCRIPTION

[0013] The present invention relates to a carrier plate arrangement according to claims 1-8 and to a method for configuring a cooling arrangement of a phased array antenna according to claims 9-10 and a phased array antenna according to claim 11.

[0014] According to one aspect of the disclosed subject matter of the present application, there is provided a carrier plate configured for mounting thereto a plurality of communication units to form a phased array antenna, said carrier plate being integrally formed with a plurality of sockets, each of said sockets being adapted to receive therein one of said plurality of communication units, wherein said carrier plate is further integrally formed with one or more cooling channels extending along said carrier plate and associated with said sockets, and configured for passage of a cooling fluid therethrough for cooling of said plurality of communication units during operation of said antenna.

[0015] Under the above arrangement, the carrier plate constitutes, within a single block of material, all of the following:

- the antenna body constituted by the sockets configured for receiving the communication unit);
- the cooling arrangement constituted by the cooling channels; and
- the supporting structure of the antenna itself.

[0016] In connection with the above, it is appreciated that this arrangement provides for a considerably simpler and more efficient design, elegantly eliminating the need for a separate cooling arrangement and/or a support structure, as common in the field.

[0017] The carrier plate can be configured for mounting thereto, on an opposite side of the sockets, a transmission module configured for connecting to the individual communication units and provide and/or receive signals therefrom. It should be noted that, despite the terms 'transmission' and 'communication', such an antenna can operate at either a transmission only mode, receiving only mode or a combination of both.

[0018] In this connection, since the cooling arrangement is integrated in the structure of the carrier plate itself (and not individually provided to each transmission module), this configuration allows for a simple plug-in of the transmission modules. Specifically, in order to mount/dismount such a transmission module onto/from the carrier plate, it is not required to attach/detach any cooling pipes or conduits. The transmission module can simply be mounted onto the carrier plate and plug into the leads of the communication units.

[0019] The arrangement can be such that when said communication units are placed within said sockets, they are in surface-to-surface contact with the carrier plate, so that there is provided heat conduction between said communication units via said carrier plate. In particular,

the carrier plate can have a cooling surface configured, when the communication units are placed, to be interposed between the cooling channel and the communication unit.

[0020] One of the advantages of the above design lies in the compact configuration of the antenna which, *inter alia*, reduced the physical distance between the communication units and the transmission module, thereby reducing losses and making the system more efficient.

[0021] In addition, since the carrier plate is made of a single, solid material, it provides the antenna with toughness and stability which are considerably high with respect to its weight, thereby reducing system errors which may be caused by deformation in the array of the communication modules.

[0022] According to a specific design, the carrier plate can be constituted by a plurality of modular carrier plate units, each being integrally formed with its own socket/s and cooling channel/s, the units being configured for successive attachment to one another to form a combined antenna of greater dimensions.

[0023] In particular, the arrangement can be such that, when two or more carrier plates are attached to one another along one direction, the cooling channels thereof are collinear and become interconnected, allowing fluid communication therebetween. When the carrier plates are attached to one another along a second direction, different than the first, the cooling channels can be arranged parallel/angled to one another.

[0024] Per the above, when a plurality of modular units are connected to one another in any way, a distribution arrangement can be provided for interconnecting the cooling channels of each of the modular carrier plate units to provide fluid association between the channels.

[0025] When two or more carrier plates are attached to one another not along the longitudinal direction (e.g. so that the cooling channels thereof are parallel to one another), at least two configuration of the fluid distribution arrangement can be provided:

Parallel cooling, know e.g. from JP 2011-244266 or US2003/0218566, - the distribution arrangement comprises a main feed with a manifold simultaneously connected to first, inlet ends of the cooling channels and a main outlet with a manifold simultaneously connected to second, outlet ends of the cooling channels so that each of the cooling channels simultaneously receives, in parallel, a cooling fluid. Thus, at all the first ends (inlet) the cooling fluid is of the lowest temperature and at all the second ends (outlet), the cooling fluid is of the highest temperature (having removed heat from the communication units).

[0026] **In-line cooling**, known e.g. from JP 2011-244266, - the cooling channels are connected in a consecutive manner, the second end (outlet) of one channel being connected to the first end (inlet) of the

cooling channel of the consecutive carrier plate. Thus, the cooling fluid enters the first end of the first cooling channel at the lowest temperature and is emitted from the second end of the last cooling channel at the highest temperature.

[0027] However, according to a specific design of the subject matter of the present application, each carrier plate can be formed with a first cooling channel and a second cooling channel. The distribution arrangement can be configured for a unique successive connection of the cooling channels so that fluid is first forced to flow through the first channel of each of the carrier plates and only then returned through the second channel of each of the carrier plates.

[0028] With regards to the above, the cooling fluid enters the first channel of the first carrier plate at the lowest temperature t and reaches the outlet end of the first channel of the last carrier plate at a higher temperature $t' > t$. Thereafter, it is returned first through the second channel of the last carrier plate and, after passing through the second cooling channels of all carrier plate units, reaches the outlet end of the second channel of the first carrier plate unit at a temperature $T > t' > t$.

[0029] The unique arrangement above provides that the average temperature of the cooling fluid in each carrier plate is approx. t' . This arrangement allows, on the one hand, the simplicity of a successive connection between carrier plates (not requiring a manifold and not limited in size) and, on the other hand, for a uniform average temperature between all carrier plates.

[0030] The carrier plate can further be formed with a utility channel configured for accommodating therein all the necessary electronic/mechanical components required for the operation of the communication units. The arrangement can be such that the utility channel is isolated from the one or more cooling channels. In particular, in case the carrier plate is made by extrusion, the material of the carrier plate itself forms the barrier between the one or more cooling channels and the utility channel, providing said isolation.

[0031] In addition, according to one example, the modular units may be made of the same material, facilitating uniform heat conduction throughout the carrier plate. Alternatively, according to another example, each of the modular units may be made of a different material, depending on the communication unit adapted to be received in the socket thereof.

[0032] According to another aspect of the subject matter of the present application, there is provided a method for configuring a cooling arrangement of a phased array antenna comprising two or more carrier plates of the previous aspect of the present application, each carrier plate having a first cooling channel and a second cooling channel, the method includes the steps of:

- a) providing a fluid inlet associated with a first end of the first channel of the first carrier plate;
- b) consecutively attaching a second end of the first

channel of each carrier plate but last to the first end of the first channel of a successive carrier plate;

c) attaching the second end of the first channel of the last carrier plate with a first end of the second channel of the last carrier plate;

d) consecutively attaching a second end of the second channel of each carrier plate but first to the first end of the first channel of a successive carrier plate; and

providing a fluid outlet associated with a second end of the second cooling channel of the first carrier plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] In order to better understand the subject matter that is disclosed herein and to exemplify how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1A is a schematic rear isometric view of a portion of a carrier plate of the present application with a plurality of communication units attached thereto;

Fig. 1B is a schematic rear isometric view of the carrier plate shown in Fig. 1A;

Fig. 1C is a schematic front isometric view of the carrier plate shown in Fig. 1A;

Fig. 1D is a schematic rear view of the carrier plate shown in Fig. 1B;

Fig. 1E is a schematic cross section of the carrier plate shown in Fig. 1B;

Fig. 2A is a rear exploded view of the carrier plate shown in Fig. 1A;

Fig. 2B is a front exploded view of the carrier plate shown in Fig. 1A; and

Fig. 3 is a schematic isometric view of a carrier plate formation constituted by a plurality of carrier plates shown in Fig. 1B.

DETAILED DESCRIPTION OF EMBODIMENTS

[0034] Attention is first drawn to Figs. 1A to 1E in which a part of a phased array antenna is shown generally designated **1** and comprising a carrier plate **10** and a transmission module **M** mounted thereon. The phased array antenna **1** is further provided with a front cover **P**, configured for shielding.

[0035] The carrier plate **10** is made of a single extruded body having a rear surface **12** and a front surface **14**, the plate **10** having a longitudinal axis **X** defining a first direction of the plate **10** (parallel to the direction of extrusion).

[0036] With particular reference being made to Fig. 1C, the front surface **14** of the carrier plate **10** is formed with a plurality of sockets **11** configured for accommodating therein a corresponding plurality of communication units **C**, which are in turn associated with the transmission

module **M**, mounted on the rear surface **12** of the carrier plate **10**. The communication units **C** are shielded by the cover plate **P** (shown Figs. 2A, 2B).

[0037] In the course of operation of the phased array antenna **1**, the module **M** and communication units **C** generate a considerable amount of heat which is required to be removed from the antenna.

[0038] For this purpose, the carrier plate **10** is formed with a first set of cooling channels **16a, 16b** and a second set of cooling channels **18a, 18b**, each extending along the longitudinal axis **X** and being formed during the extrusion process. The cooling channels **16a, 16b, 18a, 18b** are configured for the passage therethrough of a cooling fluid for cooling the module **M** mounted onto the carrier plate **10**, and are each provided with openings at respective ends of the carrier plate **10**, configured for serving as fluid inlets or fluid outlets.

[0039] The arrangement is such that the first set of cooling channels **16a, 16b** is located at a top portion of the carrier plate **10** while the second set of cooling channels **18a, 18b** is located at a bottom portion of the carrier plate **10**.

[0040] Between the top portion and the bottom portion there extends a utility channel **15**, configured for accommodating therein the electronic wiring and utility components required for operation of the antenna. The utility channel **15** is machined out of the solid piece of the carrier plate **10** and is completely isolated from the cooling channels **16a, 16b, 18a, 18b**, so that the above electronic components are protected from coming in contact with any cooling fluid flowing within the channels.

[0041] With additional reference being made to Figs. 2A and 2B, the carrier plate **10** is configured for attachment to additional carrier plates **10** along a lateral direction, perpendicular to the longitudinal direction, in order to form a multi-plate (see Fig. 3). For this purpose, each carrier plate **10** is formed, at the bottom portion thereof with a longitudinal protrusion **19a** and at a top portion thereof with a longitudinal groove **19b**. In order to secure carrier plates **10** to each other, securing pins **17** are used, extending between the front surface **14** and the rear surface **12**, passing through the protrusion **19a**.

[0042] It is appreciated that since each carrier plate **10** is manufactured by extrusion, and since carrier plates **10** can be attached to each other successively along the above lateral direction, it is possible to construct, using carrier plates **10** of various lengths, almost any desired shape of the multi-plate for the multi-phase antenna.

[0043] The carrier plate **10** is also formed with openings **13**, extending between the front surface **14** and the rear surface **12**, each being configured for accommodating therethrough a guide port **22**. Each of these guide ports **22**, in turn, is configured for receiving therein a plug **24** connecting the communication units **C** with the transmission module **M**.

[0044] Turning now to Fig. 3, the cooling method of the modules **M** and the carrier plates **10** will now be described, and includes the following steps:

- cooling fluid at temperature T_0 is provided through the inlet **I** of the second set of cooling channels **18a, 18b** of the first carrier plate;
- the cooling fluid is then passed through the first carrier plate (sections 9, 10, 11 and 12 of the multi-plate, consecutively) being gradually heated as it absorbs heat (by convection) from the modules **M** and communication units **C**;
- the cooling fluid is then emitted from the outlet **II** of the second set of cooling channels **18a, 18b** at the opposite end of the first carrier plate **10** at temperature $T_1 > T_0$;
- the cooling fluid is then passed into the second set of cooling channels **18a, 18b** of the second carrier plate **10** (the plate immediately above it);
- the cooling fluid flows through the second carrier plate (sections 8, 7, 6 and 5 consecutively) being further heated;
- the cooling fluid is emitted from the outlet **III** of the second carrier plate at a temperature $T_2 > T_1 > T_0$;
- the cooling fluid is then passed into the second set of cooling channels **18a, 18b** of the third carrier plate **10**;
- the cooling fluid flows through the third carrier plate (sections 1, 2, 3 and 4 consecutively) being further heated;
- the cooling fluid is emitted from the outlet **IV** of the third carrier plate at a temperature $T_3 > T_2 > T_1 > T_0$.
- the cooling fluid is then passed into the first set of cooling channels **16a, 16b** of the third carrier plate **10** (i.e. the same carrier plate as opposed to the previous 2);
- the cooling fluid flows through the third carrier plate again, but in the opposite direction (sections 4, 3, 2 and 1 consecutively) being further heated;
- the cooling fluid is then emitted from the outlet **V** of the third carrier plate at a temperature $T_4 > T_3 > T_2 > T_1 > T_0$;
- the cooling fluid is then passed into the first set of cooling channels **16a, 16b** of the second carrier plate **10**;
- the cooling fluid flows through the second carrier plate (sections 5, 6, 7 and 8 consecutively) being further heated;
- the cooling fluid is emitted from the outlet **VI** of the second carrier plate at a temperature $T_5 > T_4 > T_3 > T_2 > T_1 > T_0$;
- the cooling fluid is then passed into the first set of cooling channels **16a, 16b** of the first carrier plate **10**;
- the cooling fluid flows through the first carrier plate (sections 12, 11, 10 and 9 consecutively) being further heated;
- the cooling fluid is emitted from the first carrier plate at a temperature $T_6 > T_5 > T_4 > T_3 > T_2 > T_1 > T_0$;

[0045] With reference to the above, it is observed that the average temperature of the cooling fluid in each carrier plate is essentially the same:

First carrier plate:

Second set of cooling channels - $(T_0 + T_1)/2$;
 First set of cooling channels - $(T_5 + T_6)/2$;
 Overall temperature - $(T_0 + T_1 + T_5 + T_6)/2$

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Second carrier plate:

Second set of cooling channels - $(T_1 + T_2)/2$;
 First set of cooling channels - $(T_4 + T_5)/2$;
 Overall temperature - $(T_1 + T_2 + T_4 + T_5)/2$

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Third carrier plate:

Second set of cooling channels - $(T_2 + T_3)/2$;
 First set of cooling channels - $(T_3 + T_4)/2$;
 Overall temperature - $(T_2 + T_3 + T_3 + T_4)/2$

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[0046] This method of passage of the cooling fluid through the carrier plates elegantly provides for averaging of the temperature in each carrier plate. Furthermore, it also makes sure that the temperature at one end of the carrier plate is not considerably greater/lower than the temperature at the other end of the same carrier plate (as would be the case if cooling fluid was passed in parallel simultaneously through all carrier plates). In particular, $(T_0 + T_6)/2$ (at the inlet end of carrier plate 10) is essentially equal to $(T_1 + T_5)/2$ (at the opposite end of the carrier plate 10).

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Claims

1. A carrier plate arrangement configured to receive a plurality of communication units (C) to form a phased array antenna (1), said carrier plate arrangement comprising two or more carrier plates (10), each of said carrier plates being integrally formed with a plurality of sockets (11), each of said sockets being adapted to receive therein at least one of said plurality of communication units, wherein each carrier plate is further integrally formed with at least first and second cooling channels (18a, 18b) extending along said carrier plate in a first direction and associated with said sockets, each carrier plate being further configured to allow passage of a cooling fluid through said cooling channels in order to cool said plurality of communication units during operation of said antenna, wherein the two or more carrier plates are attached to one another along a second direction, different from the first direction, so that the respective cooling channels of the carrier plates are parallel or angled with respect to one another, the carrier plate arrangement further comprising a distribution arrangement configured to interconnect the cooling channels and to provide fluid association therebetween,

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the carrier plate arrangement being **characterized in that** said distribution arrangement is configured to connect all of the first and second channels in series such that cooling fluid is first forced to flow successively through all of the first cooling channels before being forced to flow successively through all of the second cooling channels.

2. The carrier plate arrangement according to claim 1 with the carrier plates being made of a single block of material.
3. The carrier plate arrangement according to claim 2 with the carrier plates being formed by extrusion.
4. The carrier plate arrangement according to any one of the preceding claims, wherein said units, when placed within said sockets, are in surface-to-surface contact with the carrier plate, so that there is provided heat conduction between said units via said carrier plate.
5. The carrier plate arrangement according to any one of the preceding claims, wherein the carrier plate has a cooling surface configured, when the units are placed, to be interposed between the cooling channel and the unit.
6. The carrier plate arrangement according to any one of the preceding Claims, comprising two or more carrier plates attached to one another along the first direction, the cooling channels being collinear and interconnected, thereby allowing fluid communication therebetween.
7. The carrier plate arrangement according to any one of the preceding Claims, wherein the carrier plate is further formed with a utility channel (15), isolated from said cooling channels, and configured for accommodating therein all the necessary electronic/mechanical components required for the operation of the units.
8. The carrier plate arrangement according to any one of the preceding Claims, wherein said carrier plates are made of the same material, thereby facilitating uniform heat conduction throughout the arrangement.
9. A method for configuring a cooling arrangement of a phased array antenna comprising the carrier plate arrangement according to any one of the preceding claims, each carrier plate having a first cooling channel and a second cooling channel, the carrier plates being arranged so that the cooling channels thereof are not co-linear, the method includes the steps of:

a) providing a fluid inlet associated with a first

- end of the first channel of the first carrier plate;
 b) consecutively attaching a second end of the first channel of each carrier plate, but a last one thereof, to the first end of the first channel of a successive carrier plate;
 c) attaching the second end of the first channel of the last carrier plate with a first end of the second channel of the last carrier plate;
 d) consecutively attaching a second end of the second channel of each carrier plate, but a first one thereof, to the first end of the second channel of a successive carrier plate; and
 e) providing a fluid outlet associated with a second end of the second cooling channel of the first carrier plate.
10. The method according to Claim 9, wherein the cooling fluid enters the first channel of the first carrier plate at the lowest temperature t and reaches the outlet end of the first channel of the last carrier plate at a higher temperature $t' > t$, and thereafter returned first through the second channel of the last carrier plate and reaches the outlet end of the second channel of the first carrier plate at a temperature $T > t' > t$.
11. A phased array antenna comprising a carrier plate arrangement according to any one of Claims 1 to 8, and two or more communication units mounted thereon.

Patentansprüche

1. Trägerplattenanordnung, die dafür konfiguriert ist, mehrere Kommunikationseinheiten (C) aufzunehmen, um eine Phased-Array-Antenne (1) zu bilden, wobei die Trägerplattenanordnung zwei oder mehr Trägerplatten (10) aufweist, wobei in jeder der Trägerplatten mehrere Buchsen (11) integral ausgebildet sind, wobei jede der Buchsen angepasst ist, mindestens eine der mehreren Kommunikationseinheiten aufzunehmen, wobei in jede Trägerplatte ferner mindestens ein erster und ein zweiter Kühlkanal (18a, 18b) integral ausgebildet sind, die sich entlang der Trägerplatte in einer ersten Richtung erstrecken und den Buchsen zugeordnet sind, wobei jede Trägerplatte ferner dafür konfiguriert ist, den Durchgang eines Kühlfluids durch die Kühlkanäle zu ermöglichen, um die mehreren Kommunikationseinheiten während des Betriebs der Antenne zu kühlen,
- wobei die zwei oder mehr Trägerplatten entlang einer von der ersten Richtung verschiedenen zweiten Richtung aneinander befestigt sind, so dass die jeweiligen Kühlkanäle der Trägerplatten parallel oder schräg zueinander angeordnet sind, wobei die Trägerplattenanordnung ferner eine

Verteileranordnung aufweist, die dafür konfiguriert ist, die Kühlkanäle miteinander zu verbinden und eine Fluidkommunikation dazwischen bereitzustellen,

wobei die Trägerplattenanordnung **dadurch gekennzeichnet ist, dass** die Verteileranordnung dafür konfiguriert ist, alle ersten und zweiten Kanäle in Reihe zu verbinden, so dass das Kühlfluid zunächst gezwungen wird, nacheinander durch alle ersten Kühlkanäle zu strömen, bevor es gezwungen wird, nacheinander durch alle zweiten Kühlkanäle zu strömen.

2. Trägerplattenanordnung nach Anspruch 1, wobei die Trägerplatten aus einem einzigen Materialblock hergestellt sind.
3. Trägerplattenanordnung nach Anspruch 2, wobei die Trägerplatten durch Extrusion hergestellt sind.
4. Trägerplattenanordnung nach einem der vorangehenden Ansprüche, wobei die Einheiten, wenn sie innerhalb der Buchsen angeordnet sind, in Flächenkontakt mit der Trägerplatte stehen, so dass über die Trägerplatte eine Wärmeleitung zwischen den Einheiten bereitgestellt wird.
5. Trägerplattenanordnung nach einem der vorangehenden Ansprüche, wobei die Trägerplatte eine Kühlfläche aufweist, die dafür konfiguriert ist, zwischen dem Kühlkanal und der Einheit angeordnet zu werden, wenn die Einheiten angeordnet werden.
6. Trägerplattenanordnung nach einem der vorangehenden Ansprüche, mit zwei oder mehr Trägerplatten, die entlang der ersten Richtung aneinander befestigt sind, wobei die Kühlkanäle kollinear angeordnet und miteinander verbunden sind, wodurch eine Fluidkommunikation dazwischen ermöglicht wird.
7. Trägerplattenanordnung nach einem der vorangehenden Ansprüche, wobei in der Trägerplatte ferner ein Versorgungskanal (15) ausgebildet ist, der von den Kühlkanälen isoliert und dafür konfiguriert ist, alle für den Betrieb der Einheiten erforderlichen elektronischen/mechanischen Komponenten aufzunehmen.
8. Trägerplattenanordnung nach einem der vorangehenden Ansprüche, wobei die Trägerplatten aus dem gleichen Material hergestellt sind, wodurch eine gleichmäßige Wärmeleitung über die gesamte Anordnung ermöglicht wird.
9. Verfahren zum Konfigurieren einer Kühlanordnung einer Phased-Array-Antenne mit der Trägerplattenanordnung nach einem der vorangehenden Ansprüche, wobei jede Trägerplatte einen ersten Kühlkanal

und einen zweiten Kühlkanal aufweist, wobei die Trägerplatten derart angeordnet sind, dass ihre Kühlkanäle nicht kollinear angeordnet sind, wobei das Verfahren die Schritte aufweist:

- a) Bereitstellen eines Fluideinlasses, der einem ersten Ende des ersten Kanals der ersten Trägerplatte zugeordnet ist;
- b) aufeinanderfolgendes Befestigen eines zweiten Endes des ersten Kanals jeder Trägerplatte, mit Ausnahme einer letzten davon, am ersten Ende des ersten Kanals einer nachfolgenden Trägerplatte;
- c) Befestigen des zweiten Endes des ersten Kanals der letzten Trägerplatte an einem ersten Ende des zweiten Kanals der letzten Trägerplatte;
- d) aufeinanderfolgendes Befestigen eines zweiten Endes des zweiten Kanals jeder Trägerplatte, mit Ausnahme einer ersten davon, mit dem ersten Ende des zweiten Kanals einer nachfolgenden Trägerplatte; und
- e) Bereitstellen eines Fluidauslasses, der einem zweiten Ende des zweiten Kühlkanals der ersten Trägerplatte zugeordnet ist.

10. Verfahren nach Anspruch 9, wobei das Kühlfluid bei einer niedrigsten Temperatur t in den ersten Kanal der ersten Trägerplatte eintritt und das Auslassende des ersten Kanals der letzten Trägerplatte bei einer höheren Temperatur $t' > t$ erreicht und anschließend zuerst durch den zweiten Kanal der letzten Trägerplatte zurückströmt und das Auslassende des zweiten Kanals der ersten Trägerplatte bei einer Temperatur $T > t' > t$ erreicht.
11. Phased-Array-Antenne mit einer Trägerplattenanordnung nach einem der Ansprüche 1 bis 8 und mit zwei oder mehr daran montierten Kommunikationseinheiten.

Revendications

1. Agencement de plaque de support configuré pour recevoir une pluralité d'unités de communication (C) pour former une antenne réseau à commande de phase (1), ledit agencement de plaque de support comprenant deux plaques de support (10) ou plus, chacune desdites plaques de support étant formée d'un seul tenant avec une pluralité de prises (11), chacune desdites prises étant adaptée pour recevoir à l'intérieur au moins une de ladite pluralité d'unités de communication, dans lequel chaque plaque de support est en outre formée d'un seul tenant avec au moins des premier et deuxième canaux de refroidissement (18a, 18b) s'étendant le long de ladite plaque de support dans une première direction et as-

sociés auxdites prises, chaque plaque de support étant en outre configurée pour permettre le passage d'un fluide de refroidissement à travers lesdits canaux de refroidissement de manière à refroidir ladite pluralité d'unités de communication durant le fonctionnement de ladite antenne, dans lequel les deux plaques de support ou plus sont fixées entre elles le long d'une deuxième direction, différente de la première direction, de manière que les canaux de refroidissement respectifs des plaques de support soient parallèles ou angulaires l'un par rapport à l'autre, l'agencement de plaque de support comprenant en outre un agencement de distribution configuré pour interconnecter les canaux de refroidissement et pour fournir une association de fluide entre eux, l'agencement de plaque de support étant **caractérisé en ce que** ledit agencement de distribution est configuré pour connecter tous les premiers et deuxièmes canaux en série de manière que le fluide de refroidissement soit d'abord forcé à circuler successivement à travers tous les premiers canaux de refroidissement avant d'être forcé à circuler successivement à travers tous les deuxièmes canaux de refroidissement.

2. Agencement de plaque de support selon la revendication 1, avec les plaques de support qui sont réalisées à partir d'un unique bloc de matériau.
3. Agencement de plaque de support selon la revendication 2, avec les plaques de support qui sont formées par extrusion.
4. Agencement de plaque de support selon l'une quelconque des revendications précédentes, dans lequel lesdites unités, quand elles sont placées dans lesdites prises, sont en contact surface-surface avec la plaque de support, de manière qu'il soit prévu une conduction de chaleur entre lesdites unités par le biais de ladite plaque de support.
5. Agencement de plaque de support selon l'une quelconque des revendications précédentes, dans lequel la plaque de support a une surface de refroidissement configurée, quand les unités sont mises en place, pour être interposée entre le canal de refroidissement et l'unité.
6. Agencement de plaque de support selon l'une quelconque des revendications précédentes, comprenant deux plaques de support ou plus fixées entre elles le long de la première direction, les canaux de refroidissement étant colinéaires et interconnectés, en permettant ainsi une communication de fluide entre eux.
7. Agencement de plaque de support selon l'une quel-

conque des revendications précédentes, dans lequel la plaque de support est formée en outre avec un canal de service (15), isolé desdits canaux de refroidissement et configuré pour loger à l'intérieur tous les composants électroniques/mécaniques nécessaires requis pour le fonctionnement des unités.

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8. Agencement de plaque de support selon l'une quelconque des revendications précédentes, dans lequel lesdites plaques de support sont constituées du même matériau, en facilitant ainsi une conduction thermique uniforme à travers tout l'agencement.

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9. Procédé de configuration d'un agencement de refroidissement d'une antenne réseau à commande de phase comprenant l'agencement de plaque de support selon l'une quelconque des revendications précédentes, chaque plaque de support ayant un premier canal de refroidissement et un deuxième canal de refroidissement, les plaques de support étant agencées de manière que leurs canaux de refroidissement ne soient pas colinéaires, le procédé comprenant les étapes suivantes :

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a) la fourniture d'une entrée de fluide associée à une première extrémité d premier canal de la première plaque de support ;

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b) la fixation consécutive d'une deuxième extrémité du premier canal de chaque plaque de support, mais une dernière de celles-ci, à la première extrémité du premier canal d'une plaque de support successive ;

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c) la fixation de la deuxième extrémité du premier canal de la dernière plaque de support à une première extrémité du deuxième canal de la dernière plaque de support ;

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d) la fixation consécutive d'une deuxième extrémité du deuxième canal de chaque plaque de support, mais une première de celle-ci, à la première extrémité du deuxième canal d'une plaque de support successive ; et

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e) la disposition d'une sortie de fluide associée à une deuxième extrémité du deuxième canal de refroidissement de la première plaque de support.

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10. Procédé selon la revendication 9, dans lequel le fluide de refroidissement entre dans le premier canal de la première plaque de support à la plus basse température t et atteint l'extrémité de sortie du premier canal de la dernière plaque de support à une température plus élevée $t' > t$, et retourne ensuite d'abord à travers le deuxième canal de la dernière plaque de support et arrive à l'extrémité de sortie du deuxième canal de la première plaque de support à une température $T > t' > t$.

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11. Antenne réseau à commande de phase comprenant

un agencement de plaque de support selon l'une quelconque des revendications 1 à 8 et deux unités de communication ou plus montées sur celle-ci.

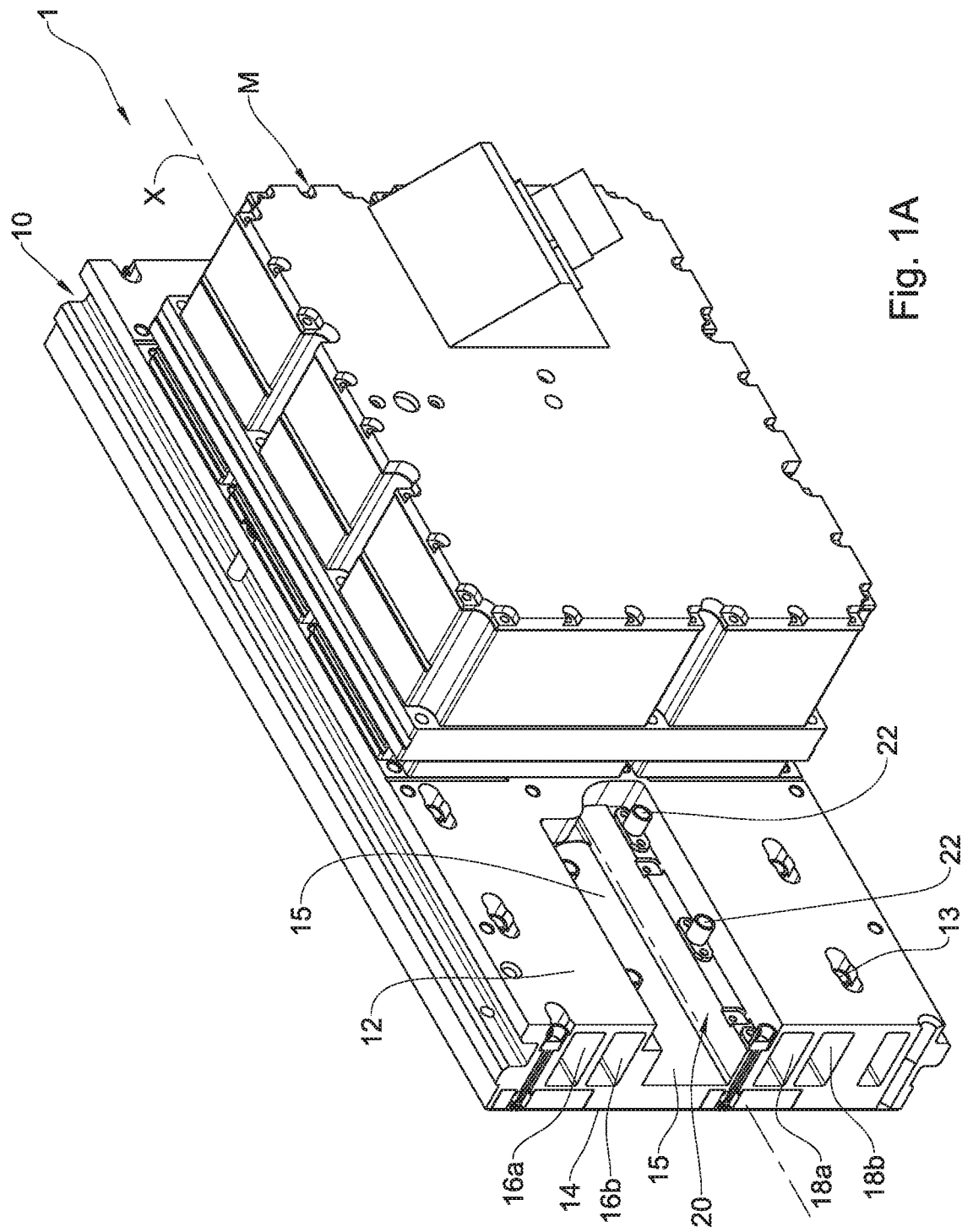


Fig. 1A

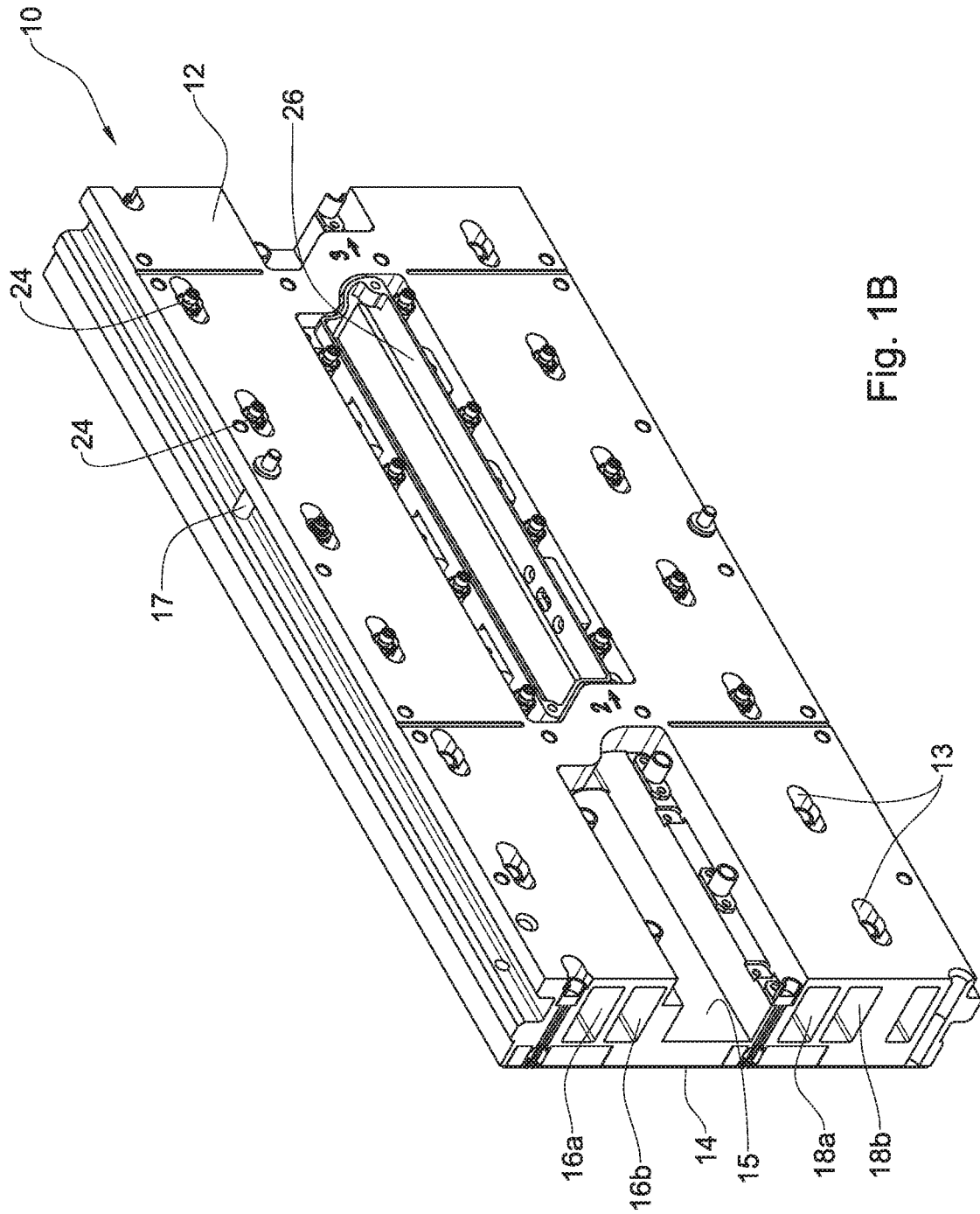
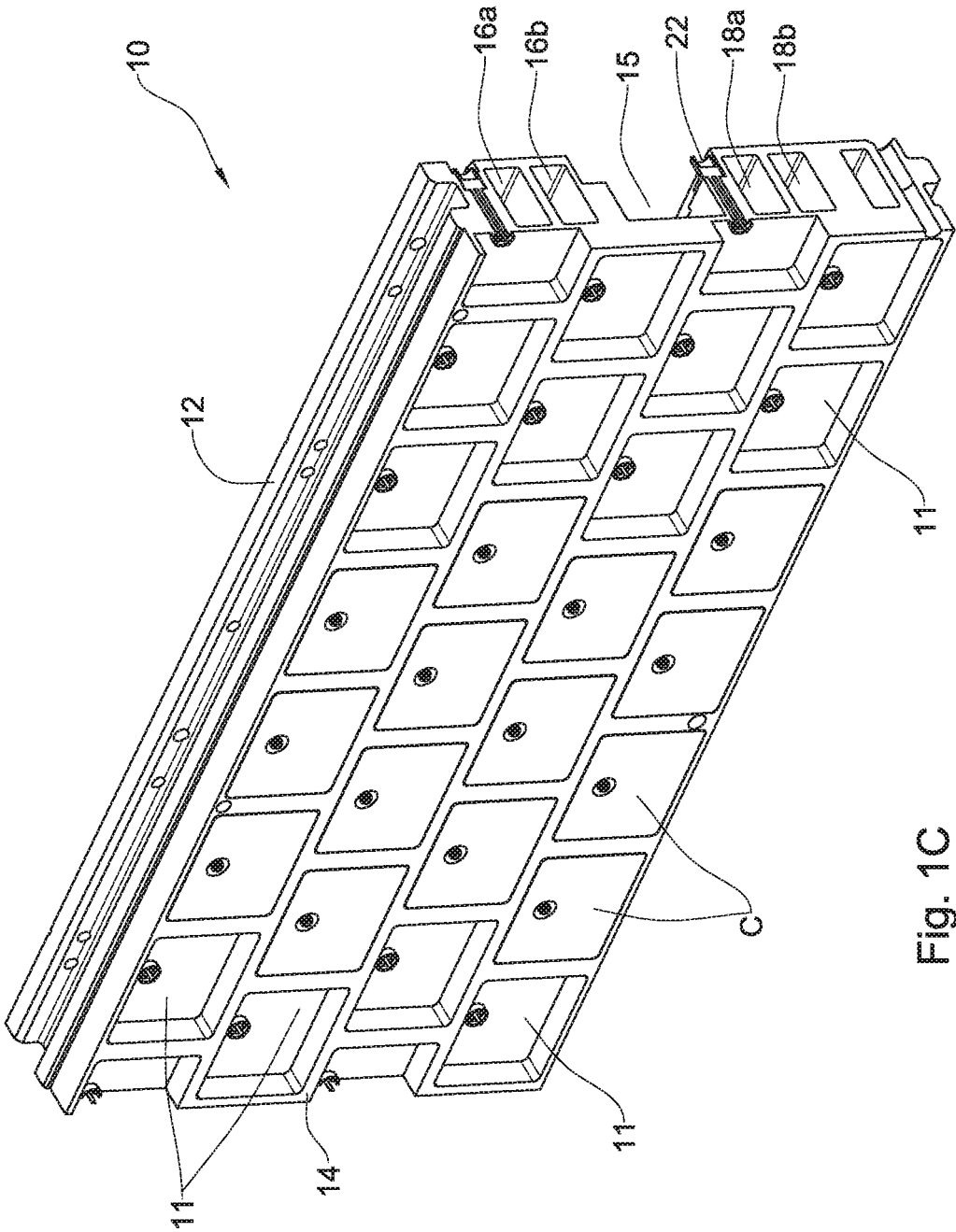


Fig. 1B



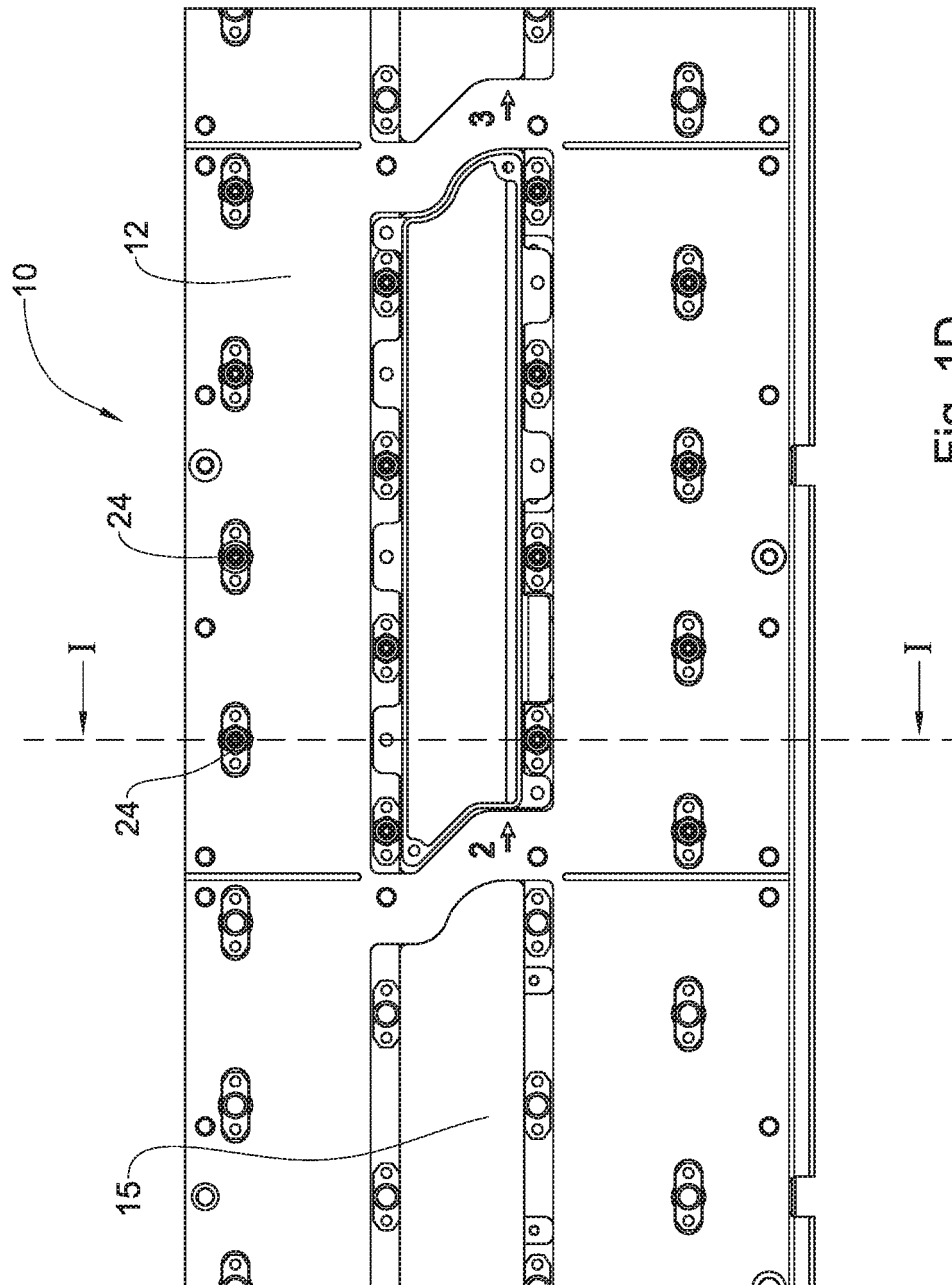


Fig. 1D

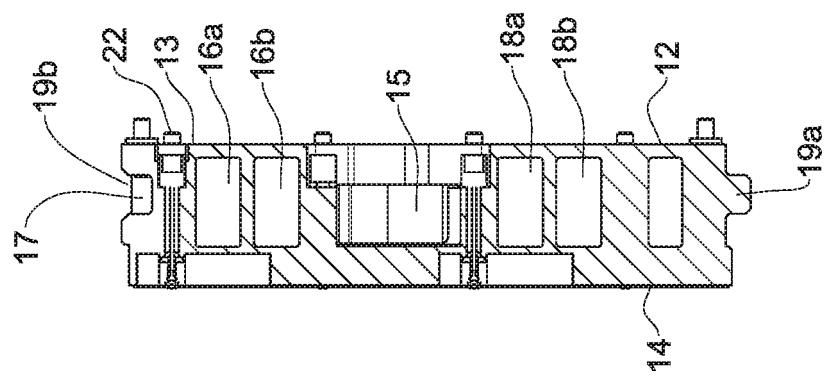


Fig. 1E

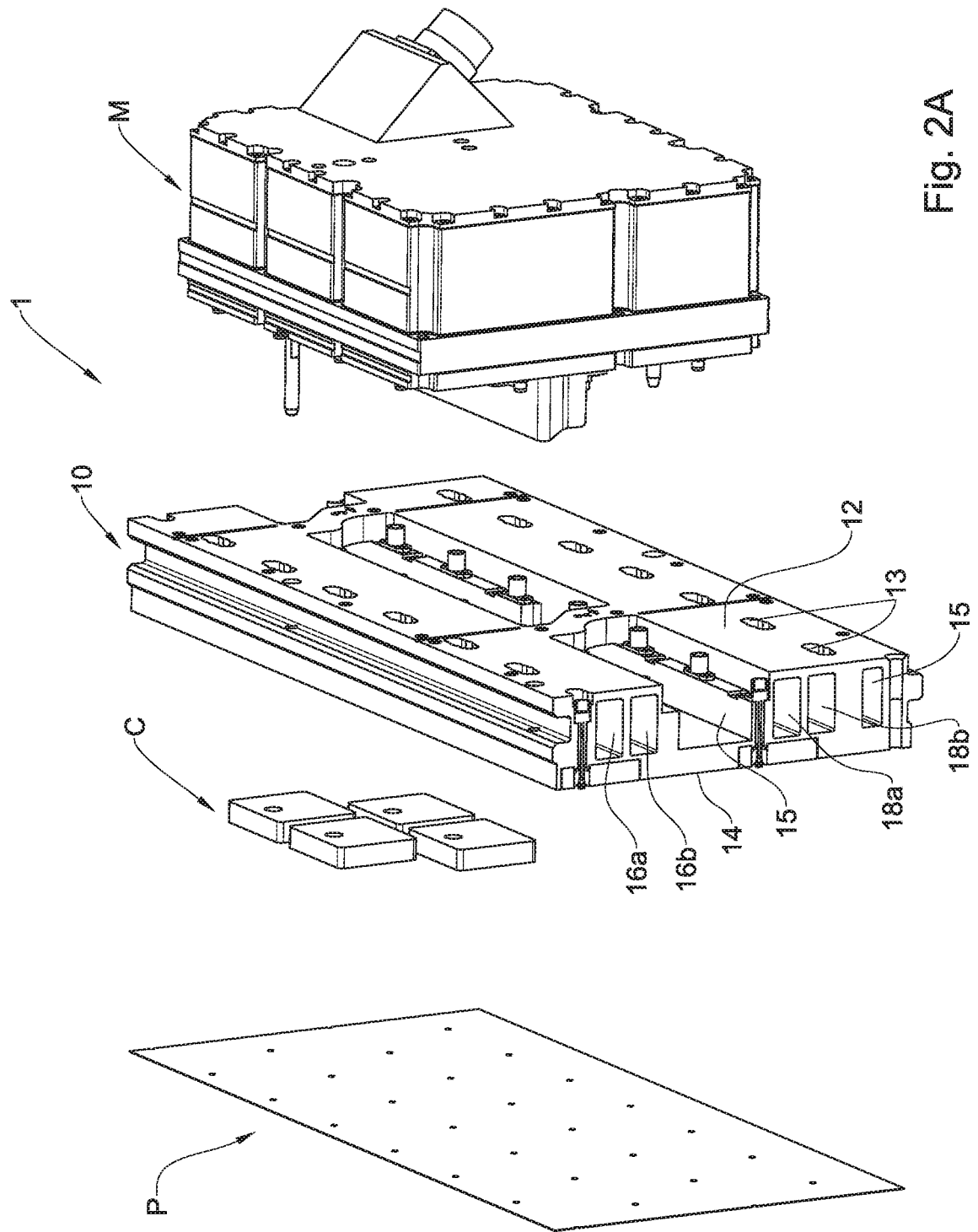


Fig. 2A

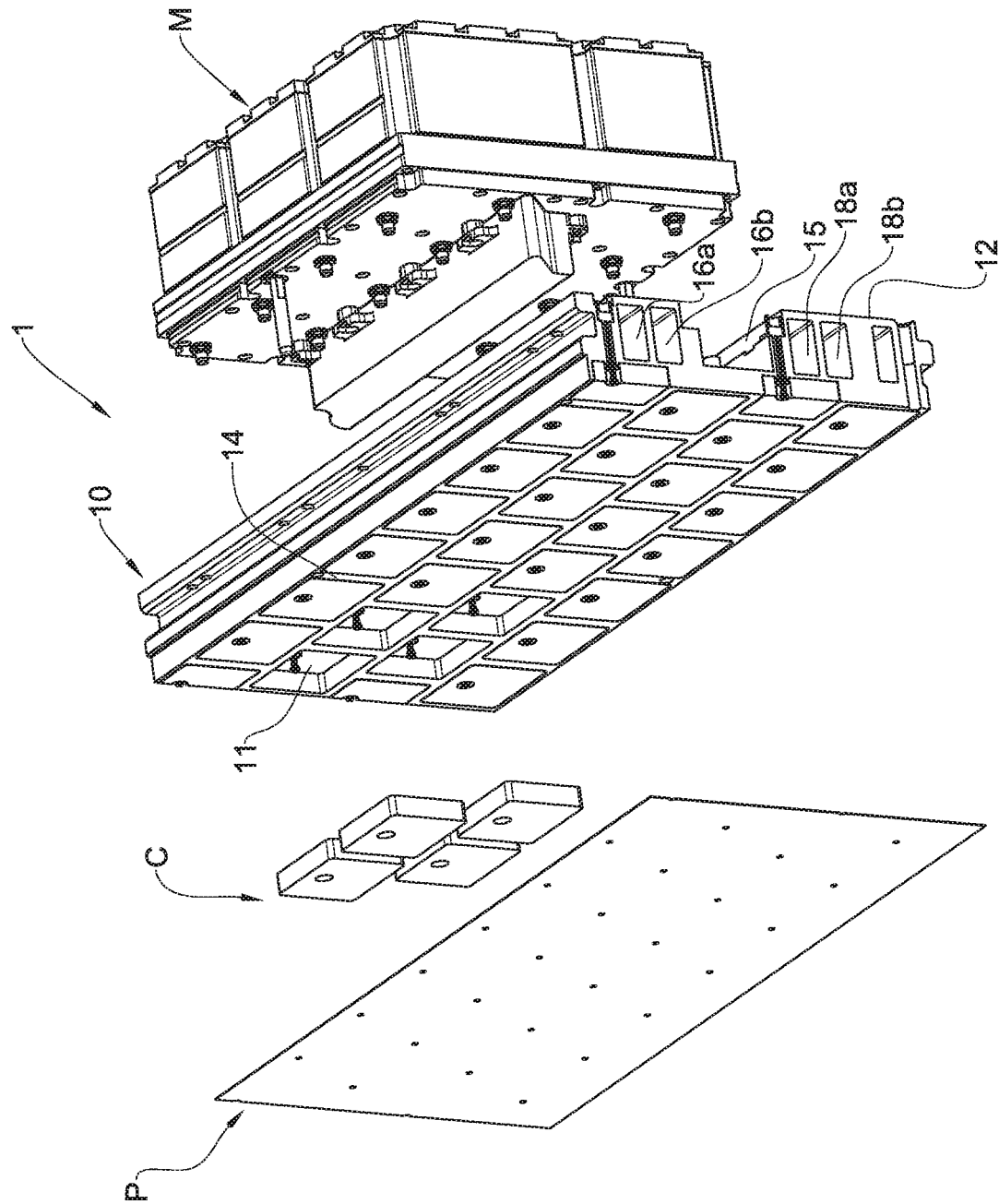


Fig. 2B

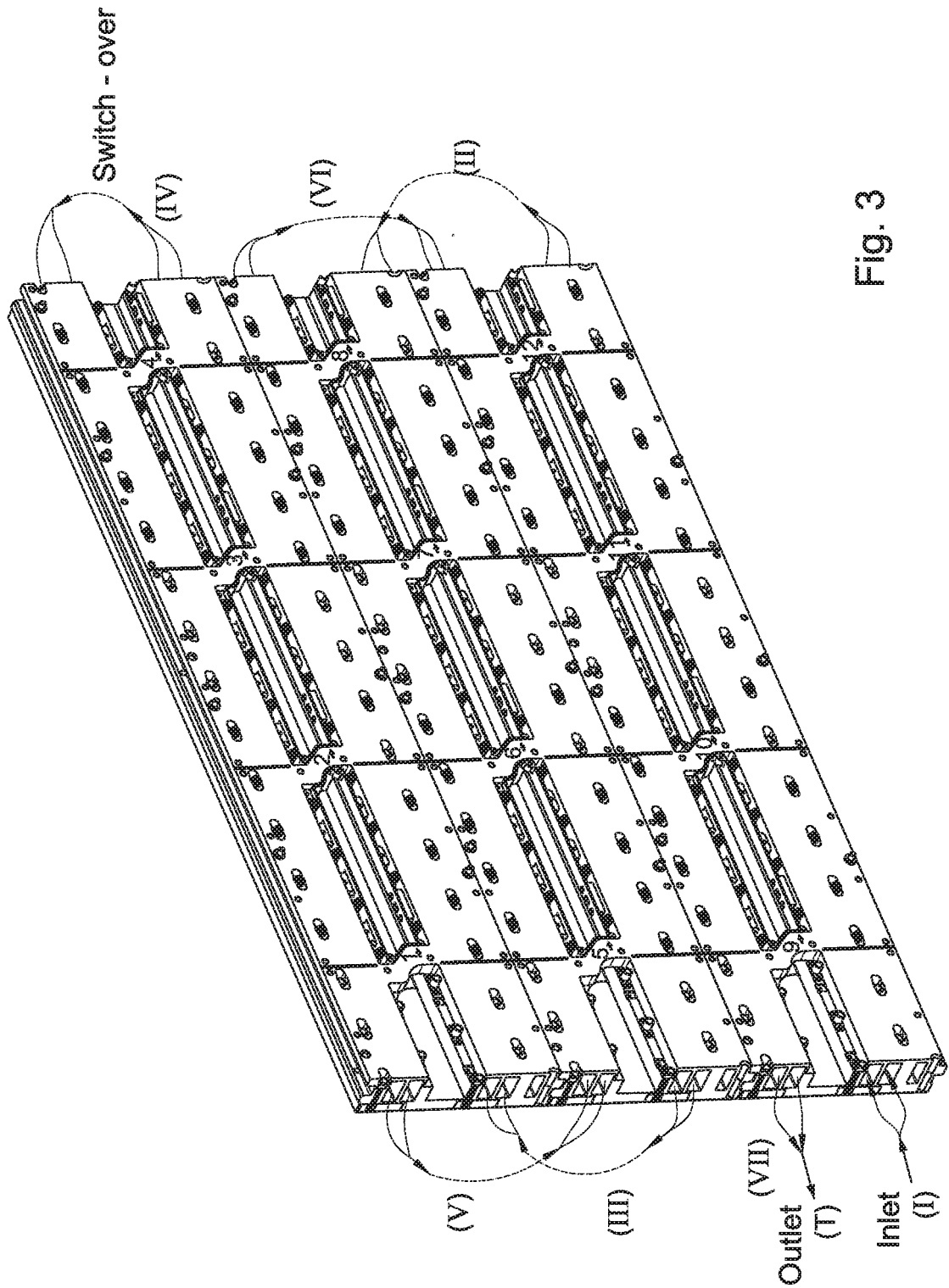


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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